Dark Matter and Cosmic Vacuum: Two States of the Same Substance

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Abstract

This paper presents a structural cosmological model that defines dark matter and cosmic vacuum within a single framework based on massive membranes and energy strings. The central idea is that:

Dark matter and cosmic vacuum are not independent entities, but two phases of the same geometry: a single structure of massive membranes, contracted in one phase (dark matter) and open in another phase (cosmic vacuum), supported by temporal-energy strings that represent dark energy.

The model organizes this on the basis of three distinct space-time patterns. Each pattern has its own structural content and effective laws, while preserving the condition that Pattern 1 inside galaxies remains conventional Einsteinian-quantum space-time, whereas what we call "vacuum," "dark matter," and "dark energy" are reformulated in Patterns 2 and 3.

Keywords: dark matter; cosmic vacuum; dark energy; massive membranes; temporal-energy strings; space-time patterns; cosmological constant; phase transitions.

1 The Three Space-Time Patterns in the Model

1.1 Pattern 1 ($\mathbf{P}_1$): Einsteinian Space-Time Inside Galaxies

Structure: Three open spatial dimensions plus one temporal dimension; a four-dimensional Lorentzian manifold with metric $g_{\mu\nu}$.

Laws: General Relativity (GR), Quantum Field Theories (QFT), Standard Model of particles.

Domain: Interiors of galaxies and galaxy clusters where baryon density is high and gravity is strong.

Role in the model: All "ordinary physics" lives here – particles, fields, quantum states, entanglement, and so forth. This pattern is local and effective, not the complete cosmic framework.

1.2 Pattern 2 (P_2): Cosmic Temporal Pattern – Dark-Matter Membrane Phase

This pattern is the level at which dark matter is defined in its initial structural phase.

Space-Time Structure:

- One cosmic temporal dimension that carries overlapping open energy strings.
- Three contracted spatial dimensions that contain separate, contracted massive membranes.

Basic Entities:

- **Energy Strings:**
  - Not super-string theory objects and not abstract "time coordinates".
  - They are temporal-energy strings, i.e., organized energy in a cosmic temporal dimension.
  - In this pattern they appear as overlapping open strings that shape the cosmic temporal structure.
- **Contracted Massive Membranes:**
  - Massive membranes residing in the contracted spatial dimensions.
  - Spatially separate and non-overlapping.
  - These membranes are what we effectively observe as dark matter.

Interpretation:

Dark matter in P_2 = contracted, separate massive membranes in contracted spatial dimensions, supported by overlapping open temporal-energy strings.

This contracted membrane phase is the primary structural reservoir of dark matter.

1.3 Pattern 3 (P_3): Cosmological Vacuum Phase – Vacuum/Dark-Energy Pattern

This pattern corresponds to what is usually called "cosmic vacuum" and "dark energy."

Space-Time Structure:

- Three open spatial dimensions hosting separate, open massive membranes.
- Three contracted temporal dimensions hosting separate, contracted energy strings.

Basic Entities:

- **Open Massive Membranes:**
  - Same type of massive membranes as in P_2, but now in an open rather than contracted state.
  - Distributed throughout the open spatial dimensions.
  - This network of open membranes is identified as the cosmic vacuum in the model.

- **Contracted Energy Strings:**
  - Energy strings in three contracted temporal dimensions.
  - These contracted strings constitute dark energy, interpreted as a compressed temporal tension driving cosmic acceleration.

Interpretation:
Cosmic vacuum in P_3 = the very same massive membranes after they transition into an open phase in open spatial dimensions.

Dark energy = contracted temporal-energy strings in three contracted temporal dimensions.

2 Dark Matter and Cosmic Vacuum as One Structure

The central claim of the model can be expressed as follows:

Dark matter and cosmic vacuum are a single massive-membrane geometry, contracted in spatially contracted dimensions (P_2) and observed as dark matter, and open in spatially open dimensions (P_3) and observed as cosmic vacuum.

2.1 Contracted Phase: Definition of Dark Matter

In Pattern P_2, massive membranes have the following properties:

- Contracted: They possess high effective thickness or density.
- Separate: They do not overlap spatially; they form distinct membrane units.
- Location: They reside inside three contracted spatial dimensions.

From the perspective of Pattern P_1 inside galaxies, the gravitational effect of these contracted membranes appears as:

- Extended halos surrounding galaxies and clusters.
- An additional gravitational pull traditionally attributed to an invisible "dark matter" component.

2.2 Open Phase: Definition of Cosmic Vacuum

In Pattern P_3, the same membranes that were contracted in P_2 become:

- Open massive membranes: Geometrically extended rather than contracted.
- Spatially separate: Still non-overlapping but now widespread in three open spatial dimensions.

This configuration:

- Fills the space between galaxies with a structured medium.
- Is perceived observationally as the cosmic vacuum, which is no longer "empty" but a membrane-based structure.

Consequently:

- There is no truly "empty" cosmic void; what we call vacuum is a phase of open massive membranes supported by contracted energy strings.
- What we call dark matter is the identical membrane structure in a geometrically contracted state residing in contracted spatial dimensions.

3 Nature of Strings and Membranes

3.1 Temporal-Energy Strings

These are not super-string objects from high-dimensional string theory. They are defined as temporal-energy strings:

- Entities that carry energy tension along temporal dimensions.
- They shape the effective structure of cosmic time in the non-Einsteinian domains.

Their roles by pattern:

- In P_2: Open, overlapping temporal-energy strings organize the cosmic temporal dimension associated with the dark-matter membrane phase.
- In P_3: Separate, contracted temporal-energy strings provide a compressed temporal tension that is physically recognized as dark energy.

3.2 Spatial Massive Membranes

These are not M-theory branes embedded in higher dimensions. They are spatial massive membranes, defined as:

- Closed or open two-dimensional surfaces within cosmic spatial dimensions.
- Their state (contracted or open) depends on the pattern.

Their roles by pattern:

- In P_2: Contracted massive membranes within contracted spatial dimensions constitute dark matter in its primary structural phase.
- In P_3: Open massive membranes in open spatial dimensions represent the effective cosmic vacuum.

4 Phase Transitions: From Dark Matter to Cosmic Vacuum

The evolution of the membrane-string structure can be divided into three broad cosmic stages:

Stage 1 – Dominance of Contracted Membranes (Dark Matter):

- Pattern P_2 dominates the large-scale structure.

- Most of the universe's massive content is stored as contracted membranes in contracted spatial dimensions.
- Dark-matter effects are strong and pervasive.

Stage 2 – Structural Transition:

- Temporal-energy string tension gradually opens the contracted membranes.
- The system transitions from a dark-matter membrane phase to a cosmic-vacuum membrane phase.
- Both patterns P_2 and P_3 are dynamically active during this stage.

Stage 3 – Dominance of Open Membranes (Cosmic Vacuum):

- Pattern P_3 becomes dominant.
- The cosmic vacuum, understood as a network of open membranes supported by contracted temporal strings, becomes the main structural component.
- As the contracted membrane phase is exhausted, the transformation from dark matter to cosmic vacuum approaches completion.

In this framework:
The evolution from "dark matter" to "cosmic vacuum" is a phase transition inside one membrane-string structure, not a replacement of one particle species or fluid by another.

5 Theoretical Black Holes and Energy Redistribution

At the level of individual galaxies, the model distinguishes:
Real Black Holes (in P_1):

- Standard GR black holes associated with collapsed visible matter (stars, gas, plasma).
- Behave essentially as in classical general relativity.

Theoretical Black Holes (galaxy-scale gravitational reservoirs):

- Represent stable gravitational energy configurations specific to each galaxy.
- Act as organizing centers that bind and structure the contracted massive membranes (the dark-matter halos) around galaxies.
- When their membrane support is lost or reconfigured, their stored gravitational energy is redistributed as separate contracted energy strings in temporal dimensions, thereby increasing the dark-energy content.

Thus, within this model:

- Gravitational energy can be transferred from a membrane-dominated configuration (dark-matter halos) to a string-dominated configuration (dark energy) without introducing new particle species.
- The interplay of real black holes (P_1) and theoretical black-hole reservoirs (linking P_1 to P_2/P_3) provides a mechanism for the exchange between dark-matter and dark-energy phases at the structural level.

6 Conceptual and Observational Implications

Several important implications follow from this structural picture:

No Dark-Matter Particles:

- Dark matter is not a gas of unknown particles.
- It is the effective gravitational manifestation of contracted massive membranes in contracted spatial dimensions.
- The persistent failure of direct-detection experiments is therefore expected, not problematic.

Vacuum as a Structured Phase:

- The cosmic vacuum is not the ground state of quantum fields defined on a single Einsteinian space-time.
- Instead, it is an open-membrane phase of the same structure that produced dark matter, now stretched across open spatial dimensions and supported by contracted temporal strings.

Unified View of Dark Matter and Dark Energy:

- Dark matter corresponds to the contracted phase of membranes (plus associated temporal structures) in P_2.
- Dark energy corresponds to contracted temporal-energy strings in P_3, acting on the open-membrane vacuum.
- Both phenomena emerge from the same underlying system of massive membranes and energy strings arranged differently across P_2 and P_3.

Domain-Dependent Laws:

- The success of GR + QFT in P_1 does not imply that the same description must hold in P_2 and P_3.
- Misapplying P_1 physics to P_2/P_3 is precisely what produces the "mystery" of dark components in the standard picture.

7 Structural Mathematics of the Framework

The present model operates within a distinct structural-organizational mathematics that differs fundamentally from both general relativity and quantum field theory. This mathematics is not built on differential equations or Hilbert spaces, but on geometric nuclei of mechanical dynamics—self-contained systems whose evolution is governed by internal relational logic rather than external forcing.

In this framework, the three pure energy strings that constitute dark energy (electromagnetic, strong nuclear, and weak nuclear) are treated as mathematical nuclei with the following properties:

Non-quantum, non-relativistic nature: These strings are not vibrating quantum objects nor relativistic field excitations. They represent ternary geometric units (x_1, x_2, x_3) that combine via a structural composition rule

$$\oplus_t(x_1, x_2, x_3) = x_{\text{effective}}$$

to form a closed temporal string. This $3 \to 1$ rule mirrors the fundamental structure of the cosmos itself, analogous to the three spatial dimensions or the three fundamental forces, and reflects the "ternary composition" principle noted in the model's earlier formulation.

Independent of local fields: While the electromagnetic and nuclear energies within P_1 (galaxies) are described by standard QED and QCD, the three pure energies in P_2/P_3 exist outside Einsteinian spacetime. They constitute a topological core rather than a force field, representing the fundamental geometry of cosmic time. This is why the previous paragraphs explicitly separate the energy of P_1 fields from the "pure" energies of the cosmic strings.

The cosmological constant as a structural invariant: The small observed value of Λ emerges naturally from this mathematics. The absolute tension of each pure energy string $T_{\text{string}} \sim \ell_{\text{Planck}}^{-2}$ is exponentially damped when distributed across the network of open massive membranes in P_3. This structural damping—not fine-tuning—explains why Λ is $\sim 10^{-120}$ in Planck units. The effective cosmological constant is simply the average geometric tension of the three energy nuclei across cosmic scales.

Mathematical formalism: The model employs a partial-order structure $(X, \leq, \oplus_t, \oplus_s, \gamma, \Psi)$ where X represents geometric units (strings/membranes), $\leq$ defines hierarchical relationships, and $\oplus$ operations describe composition. This avoids the "categorical mistake" of imposing differential geometry on cosmic vacuum, instead using compositional logic that captures the inherent granularity of space-time. Consequently, the "vacuum" is treated as a Hilbert-space-like organizational core rather than a sum of local field contributions.

This structural mathematics resolves the cosmological constant problem not by canceling or tuning energies, but by recognizing that the constant is not a parameter of quantum fields, but a geometric invariant of the cosmic string-membrane structure. The three pure energies—each absolute and maximal at its core—produce a vanishingly small effective Λ precisely because their tension is distributed across a vast, discontinuous network of membranes rather than summed linearly.

8 Conclusion

This model offers a coherent structural answer to the question of how dark matter and cosmic vacuum are related:

Dark matter and cosmic vacuum are not two different substances. They are two geometric-structural phases of a single massive-membrane configuration: contracted in contracted spatial dimensions, it is observed as dark matter; open in open spatial dimensions, it is observed as cosmic vacuum. Temporal-energy strings, overlapping and open in P_2 and contracted in P_3, form the cosmic temporal-tension framework that explains dark energy and accelerated expansion without invoking exotic particles or arbitrary constants.

Within this unified picture:

"Dark matter", "cosmic vacuum", and "dark energy" cease to be three separate conceptual problems. They become different manifestations of one system of massive mem-

branes + energy strings across three distinct patterns of space-time. This structural unification provides a foundation for further mathematical development and observational tests, while protecting the central claim in a clear and professional research form.

9 Note on Dark-Matter Depletion and Cosmic End State

In this model, dark matter is not constant in time. Its quantity at the beginning of the universe is larger than at present, and it is inevitably depleted as contracted membranes gradually open and transform into cosmic vacuum.

Over cosmic history:

- Contracted membranes (dark matter) are progressively converted into open membranes (cosmic vacuum).
- When dark matter is completely exhausted, the cosmic expansion driven by this transformation comes to an end.
- In the final stage, the entire cosmic vacuum phase reconverges into a single cosmic bubble, representing the ultimate large-scale configuration of the membrane-string structure.

10 References

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